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Interdependence, a blessing or a curse?

Choosing economic interdependence levels given the possibility of conflict

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Abstract

Bilateral trade creates varying levels of economic interdependence between two countries. In this paper, I study using a game theoretical model how the choice of economic interdependence in bilateral trade is made, when there is the possibility of conflict. Interdependence increases the incentive to trade but also the incentive for conflict. Moreover, by the use of financial sanctions and financial aid, outside countries can influence the decisions of the countries engaged in bilateral trade. In addition, the characteristics of a domestic country can be used to determine the objectives behind a foreign country's trade proposal.

1.Introduction

The Chinese Belt and Road Initiative (BRI) is a transcontinental policy that develops connectivity and interconnectedness among six main economic corridors (OECD, 2018). As of March 2022, 146 countries had signed cooperation agreements for the BRI over the period of 2013 to 2022. Additionally, about $890 billion investments have been made in BRI countries (GFDC, 2022). The five main goals of the BRI are: "policy coordination, facilities connectivity, unimpeded trade, financial integration, and people-to-people bonds" (GFDC, 2022). This in turn would create a high level of interdependence among BRI countries including economic and political interdependence.

This initiative is reminiscent of the Silk Road which began in 138B.C. in order to connect regions in Asia, Europe and North Africa for the purpose of trade exchange, cultural exchange, technology exchange and ideologies exchange (UNESCO). The Silk Road was very successful and increased trade significantly and also improved both the ease and efficiency of trade among the regions. However, the Silk Road also brought with it some drawbacks. Firstly, the Silk Road was very essential in the conquest by the Mongols to create the Mongol empire, which controlled regions ranging from East Asia to Eastern Europe. The Mongols used the Silk Road for fast communication and additionally conquered numerous countries connected by the Silk Road. The benefits and drawbacks of the Silk Road portray the potential benefits and drawbacks of interdependence. In this example, the Silk Road was used by a third party for war, however how could the Silk Road be used by the initiating country? Therefore what effects would the BRI would have on modern day society. Will it facilitate trade openness and cultural exchange on a ground-breaking level. Or would it facilitate military conflict? This is particularly important when considering the first world war happened during the first era of increased globalization. Therefore the research question is:

"How is the choice of economic interdependence affected by the possibility of international militarized conflict?"

The research question investigates the manner in which the choice of international trade is affected by international militarized conflict and how that further affects the choice of interdependence. Economic interdependence can be described as the "measure of economic transactions between two countries" (Cooper, 1985). There are varying levels of economic interdependence raging between high interdependence and low interdependence. Some of the benefits of economic interdependence include increased efficiency through specialization. However, a cost of interdependence is the increase of economic vulnerability through decision making costs, hold up problems and more. Militarized conflict is when states challenge each other with the use of military force. A main benefit of militarized conflict is control of resources, whereas a main cost is the financial cost. Consequently, this question allows for an analysis of the interaction of the benefits and costs of economic interdependence and militarized conflict in a bilateral trade relationship.

This topic is socially relevant because the rate of globalization is increasing due to the improvements in technology and communication. As a result, it is important to understand how country's probabilities for conflict will further affect the choice of economic interdependence. This is a major concern when considering that the first World War also happened during a period of rapid globalization. For example, the USA and China are highly interdependent given their high trade volume (Lee, 2020) however, the high level of trade has resulted in significant negative income distributional changes, such as the loss of manufacturing jobs (Pierce & Schott, 2016). This has led to the potential for the decoupling of their economies from each other and also the speculation of a war between both countries. As China and the USA are two major world economies, it is important to note that a war between them would have negative economic effects globally. Therefore, through the results from this model further understanding can be brought to this topic and potential policies can be explored on how to approach international trade.

This topic is scientifically relevant because there is no consensus on whether international trade negatively or positively affects conflict. The liberal school often stresses the benefits of economic interdependence whereas the realist school focuses more on the negative costs of economic interdependence (Barbieri, 1996; Polachek, 1980). Additionally, previous literature have mainly used empirical analysis to investigate the topic (Barbieri, 1996; Gasiorowski, 1986). On the other hand, this paper will create a model, focusing on the relationship between economic interdependence through bilateral trade and armed conflict.

In this paper, I study how economic interdependence distorts the benefits of trade and the incentives for conflict. I use a dynamic model with two stages to model bilateral trade with two agents which are two countries. I study under which conditions economic interdependence negatively affects military conflict and under which conditions it positively affects military conflict. Additionally, through the extensions to model, I theorize how outside incentives and different objectives further affect the

choice to trade. Based on the propositions of the model, I will propose possible policy implications. In order to investigate the research question, firstly there will be a literature analysis in section 2 in order to create a theoretical background for this topic. In section 3 the theoretical model will be introduced and solved with relevant propositions. This will be followed by two extensions to the model in section 4. Afterwards, there will a discussion and summary of the main implications and findings from the paper.

2. Literature Review

In the literature review, relevant papers are focused on that highlight the conflicting views on the realist and liberal theories of the effect of trade on conflict. Additionally, there will be a discussion of papers that argue there is no causal relationship between interdependence and war and an analysis of the papers on which the model used in this paper is adapted from.

Firstly, pre-World War 1 literature had a very optimistic view in which it was strongly accepted that the increasing interconnectedness of the world will reduce or perhaps eliminate the possibility of conflict. Angell (1910) argues in his book, *The Great Illusion* that the costs of war are too high because of the increased level of economic interdependence among countries. In other words, Angell portrayed that war had become unprofitable, however this was mainly interpreted as war becoming impossible. Given the occurrence of the First World War a few years after the book release, there was a notable change in the conception of the ideas proposed in the book by Angell.

Similar to Angell, Polachek (1980) creates a theoretical model that asserts that there is an inverse relationship between international trade and conflict in bilateral trade. This is based on the conclusion from the Ricardian model that through specialization countries can benefit from trade, hence maximizing their social welfare. Furthermore, the model finds that increased interdependence reduces the possibility of conflict because increasing interdependence increases the costs of conflict such as through negative effects on the terms of trade. A limitation of this paper is that it focuses on bilateral trade in isolation and does not account for outside incentives that could affect the incentives for trade and conflict. This limitation is explored in this paper by including outside incentives with the use of financial sanctions and aid in Section 4.1. On the other hand, Arad and Hirsch (1981) investigate the effect of bilateral trade on producers and consumers when their countries were previously at war. The authors conclude that the expansion of the tradeable sector due to the inclusion of goods that were previously non traded, provide the most substantial gains from trade. This effect is even more prominent when both countries in question are neighbouring countries with a potentially highly interdependent relationship. Therefore, with significant benefits from trade during peace, producers and consumers would have a positive attitude towards war. This paper contributes two main factors to the existing literature. Firstly, the attitudes of producers and consumers towards peace and war have significant effects on how governments respond internationally. Secondly, there is significant

opportunity for previously warring states to have a mutually beneficial trade relationship afterwards. This is evidenced by Germany's inclusion in the European Union. This is why in my paper, the model used considers two countries who share a territory to allow for significant benefits of interdependence. Additionally, in this paper interdependence is allowed to take a range of values which provides insight as to how different levels of interdependence affect the choice of trade and war.

Mansfield (1994) uses an empirical study to investigate not only how trade affects war but also how war affects international trade. He concludes that the level of international trade has an inverse relationship with the incidence of major-power wars. He also finds that during periods of major power wars, there was reduced trade and that wars with major power countries reduce global trade. However, in the after war period, trade only has an inverse relationship with war after three years and five years. This is contrary to the conclusion by Arad and Hirsch, because Mansfield (1994) indicates that after a warring relationship, during the first three periods, trade has a positive effect on the incidence of war. Russet et. al (1998) investigate the Kantian tripod for perpetual peace which states that economic interdependence, international law and democracy establish the foundations for perpetual peace. Through empirical analysis of country pairs in the period 1950-1985, the three factors were statistically significant and independently contributed to peace between states. This paper focuses in particular on international law through the use of international organizations. Through that, the paper finds a reverse causal relationship in which countries in international organizations are less likely to have conflict, and countries who have had conflict are less likely to join international organizations together. A limitation of this paper is it only focuses on the Cold War Era which could exaggerate the benefits of international organizations. The above papers, highlight the liberal view of the deterrent effect of interdependence on (military) conflict.

On the other hand, Barbieri (1996) predicts that both asymmetrical and symmetrical extensive economic interdependence increases the likelihood of interstate militarized disputes between two countries. Barbieri argues that the benefits of increasing interdependence through trade follow a reverse U shape, hence at a certain increased level of interdependence, the benefits reduce. However, the associated costs of interdependence increase exponentially as interdependence increases. Therefore at a certain level, the interdependence costs outweigh the benefits which would in turn increase the propensity for conflict. Barbieri additionally concludes that symmetrical trade relationships have the highest deterring effect on the probability of conflict. However, a limitation in the paper by Barbieri is the lack of an adequate assessment of the costs and benefits of interdependence. This limitation is exploited in my paper through the inclusion of relevant parameters that account for these in the model through their distortion of the gains from trade and incentives for conflict.

Similarly, Goenner (2010) finds that increasing economic interdependence by bilateral trade in goods that increase state vulnerabilities increases the probability of conflict. This is because bilateral trade can increase the likelihood for shortages thereby increasing the international tension between countries. Therefore, Goenner concludes that the pattern and volume of trade are relevant factors that determine how trade affects peace. This stems from the conclusion by Gilpin (1977) where he highlights that interdependence increases insecurity regarding the continuous supply of important strategic commodities. An interesting paper by Gasiorowski (1986) examines cross national evidence and finds that increasing economic interdependence increases the probability of interstate political
conflict. However this can also reduce the probability of interstate political conflict. The paper concludes on mixed consequences because the beneficial aspects of trade reduce conflict but the costly aspects of trade increase conflict. A limitation of this paper is that it does not explore how these costly and beneficial aspects of trade interact in the real world, therefore, this paper does not provide much resolution on the opposing views of the liberal and realist arguments.

Although there has been a discussion on papers which highlight either the view that trade promotes peace or trade promotes war. There are papers that have concluded that interdependence has no effect on military conflict through statistical analysis and case studies. Firstly, Blanchard and Ripsman (1995) use a case study from which they concluded that interdependence has no relationship with military conflict. The authors created a strategic goods test which identifies the important commodities for war, alternative sources of those goods and the supply in case of war. The authors apply the test to the decision making among German leaders during the 1914 July crisis. They find that despite the vulnerabilities, the German leaders still decided to go to war. This was similar to the ignorance of vulnerabilities when the West responded to Germany in 1936. The authors aimed to prove the assumption that decision makers are not restrained from choosing war because of the costs of negatively impacting an interdependent relationship. This assumption is not followed in my paper because interdependence could still have been relevant in both scenarios but had a reduced benefit than war. Additionally, as it is a case study, the assumption of rational actors is not accounted for which is a relevant assumption in my paper. Kim (1995) used probit equations to investigate the reciprocal and one directional effects of conflicts on trade using data from 1948-1986. Similar to the conclusion by Blanchard and Ripsman (1995), Kim (1995) found through statistical analysis a lack of statistical significance for the role of economic interdependence in the probability of war. However, lack of statistical significance does not prove lack of a causal relationship considering there could be omitted variable bias such as the attitudes to trade among producers and consumers.

The model used in this paper is based on the model created by Dorussen (1999), in which the relationship between trade, power and the incentives for military conflict are analysed simultaneously. The paper uses a multi-country model with multiple periods and realist assumptions about conflict to

analyse how trade impacts the expectations of gains from conflict. Dorussen concludes that the deterrent effect of trade on conflict reduces as the number of countries increase, therefore globalization would reduce the beneficial impact of trade. On the other hand, in my paper the number of countries is not explored as a factor since the paper focuses solely on bilateral trade. However, my paper would analyse how outside incentives from other countries such as sanctions affect the incentive for military conflict between two countries. Hegre (2004) adapts the model by Dorussen (1999) to investigate the simultaneous relationship between trade, size asymmetry and militarized conflict. The aim of Hegre's paper was to investigate if symmetrical trade dependence between two countries is required to reduce the probability of interstate conflict. Similar to Barbieri(1996), Hegre concludes that the deterrent effect of trade on the probability of interstate conflict is highest for countries with symmetric trade. However, Hegre concluded that his paper did not identify any conditions in which size asymmetry increased conflict between states. The validity of this conclusion would be tested in my paper by introducing interdependence as a condition, and investigating how the size asymmetry of two countries affects the gains from trade, incentives for conflict and probability military success. Additionally, the conceptualization of interdependence in my paper is different to the conceptualization in Hegre (2004), which would be explained more in Section 3.

Wagner (1988) uses a model of bargaining theory to investigate the relationship between economic interdependence and political influence. He concludes asymmetrical dependence does not imply that the less dependent country has political influence over the other country. This theory is modelled in my paper, by assuming asymmetric dependence does not affect political influence but instead affects the shares of gains of trade and the costs of interdependence.

3. Model

3.1 Model Introduction

The dynamic game visualizes the decision of an agent to choose an interdependence level and based on that choice, choose how they want to interact with the other player. The game has two stages and decisions by both players are made simultaneously in both stages. Two players exist representing government decision makers in each country. Principal 1 for country 1 and a Principal 2 for country 2 who are each represented by P_1 and P_2 respectively. Both players are risk-neutral and rational, therefore each player aims to maximize utility. All players have perfect information. In the first stage, each player decides to have a highly interdependent relationship or have a low interdependent relationship. In the second stage, each player has two choices if in a highly interdependence relationship: to go to war or to trade. If the players are in a low interdependent relationships, then in the second stage they will only have no trade. The assumption that players cannot war in the second stage is a simplifying assumption in order to focus on how the benefits of high interdependence affect

the motivation to trade or war. Additionally, the opportunity to war in a low interdependent relationship is explored in Section 4.2 of this paper.

In the first stage, if either player chooses to have a low interdependent relationship, irrespective of the decision of the other player, both players will have a low interdependent relationship. If, both players choose to have a high interdependent relationship then there is a cost, represented by H which is the cost of interdependence. H is based on the assumption that there is a cost to interdependence. This cost could represent the cost to formulating the trading agreement and the cost of changing the supply chains within each country to accommodate for the other. If there is a low interdependent relationship, then H is equal to 0.

Table 3.1.1: Choice of Both Players in the First Stage with Outcomes

Player 1 / **Player 2**	Low Interdependence	High Interdependence
Low interdependence	Low Interdependent Relationship	Low Interdependent Relationship
High Interdependence	Low Interdependent Relationship	High Interdependent Relationship

The second stage of the model is an adaptation of the model used in Dorussen (1999), I will explain the relevant parts used in my model here. There are two countries sharing a territory between them and there are economies of scale, which is adapted from a model by Snidal (1991). The economies of scale instead would be represented by the benefits of interdependence, as countries can now pair their units with units from the other country (Hegre, 2004). The benefit of interdependence will be modelled by parameter, *b*. *b* is greater than 1 in a highly interdependent relation and this is based on the assumption that by being highly interdependent, both countries are able to benefit more from trade than a low-interdependent relationship can. On the other hand, *b* is equal to 1 for a low trading relationship. *b* represents a multiplier effect that affects the trade volume and is the same for both countries.

The decision to trade has to be made by both players for them to have a trading relationship. If there is a trading relationship, the income for both countries is equal to their domestic production plus each player's share from the gains of trade. Both countries share the income from trade and the share for both countries is not always equal. This is based on the assumption that one country can benefit relatively more from the trading relationship such as if that country is the net exporter. The share of the trade income will be modelled by parameter *D*. D_1 and D_2 for Player 1 and Player 2, where $D_1 + D_2 = 1$. Additionally D_1 and D_2 for both countries are equal to 0.5, hence both countries share the income from trade equally. In this model, domestic production for both countries is exogenous and represented by W_1 and W_2 for P_1 and P_2 respectively. Trade volume is also exogenous and is modelled by parameter, *T*.

If either player chooses to go to war, then irrespective of the decision of the other player, both countries would be in war. In the basic model, the probability of winning the war is equal for both agents *(Pr(winning)* = 0.5), if both agents choose to go to war. However if only one agent chooses war, then the probability of winning for that agent is Pr_{wa}, *Pr(winning)* > 0.5. Whereas for the other agent Pr_{wd}, (winning) < 0.5. This is based on the assumption that there is a first mover advantage for the agent which chooses war such as improved strategies and a strong defence. The probability of winning is always less than 1 and is based on the assumption that each player always has a chance to win maybe for example by extreme luck or terrible strategies by the other player. If there is a war, the player who loses has a total income of 0 and loses all resources. The player who wins controls all resources and therefore has an income of their domestic production plus the production of the other country. Each country has an unavoidable cost of war which is *c* for each player. The model is represented in Fig 3.1.1 with the choices each player faces at every stage of the game.

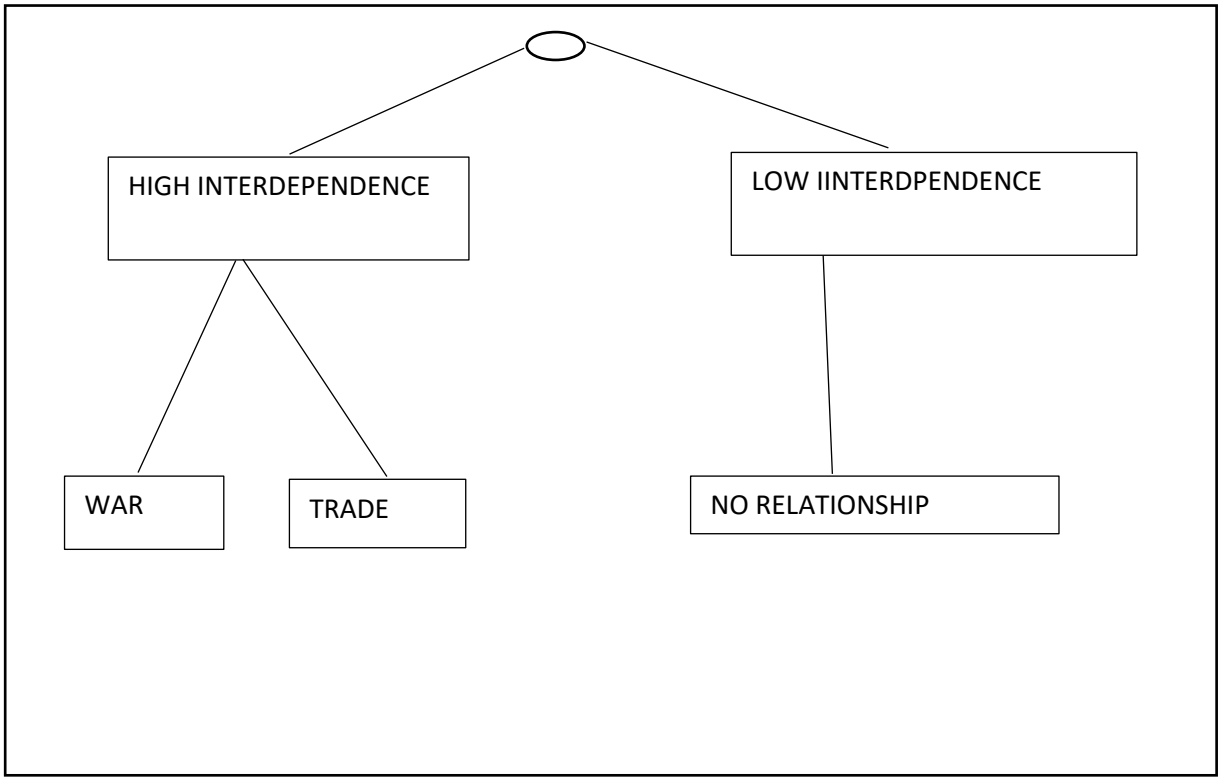

Fig 3.1.1: Basic Model Tree Form

In order to determine the payoffs, each decision shall be considered separately. Consider the decision under a low interdependence relationship. If either player chooses a low interdependence relationship then both players automatically have no relationship in the second stage. Therefore their payoffs are equal to the domestic production of each player. In a low interdependent relationship, the cost of interdependence, H = 0. Consequently, payoffs for each player under low interdependence is:

Payoff Low Interdependence for $P_1 = (Prd_1) = W_1 - 0$

Payoff Low Interdependence for $P_2 = (Prd_2) = W_2 - 0$

This is not a surprising result, as if two countries have no trade then each income cannot be greater than what they can domestically produce individual.

Consider the second stage under a high interdependence relationship. If both players choose trade, then their payoffs are:

Trade Payoff for $P_1 = W_1 + b * 0.5 * T - H$

Trade Payoff for $P_2 = W_2 + b * 0.5 * T - H$

If only player 1 chooses war:

Payoff War for $P_1 = Pr_{wa} * (W_1 + b * W_2) + (1 - Pr_{wa}) * 0 - c - H$

Payoff War for $P_2 = Pr_{wd} * (W_2 + b * W_1) + (1 - Pr_{wd}) * 0 - c - H$

If only player 2 chooses war:

Trade Payoff War for $P_1 = Pr_{wd} * (W_1 + b * W_2) + (1 - Pr_{wd}) * 0 - c - H$

Trade Payoff War for $P_2 = Pr_{wa} * (W_2 + b * W_1) + (1 - Pr_{wa}) * 0 - c - H$

If both players choose war:

Trade Payoff War for $P_1 = 0.5 * (W_1 + b * W_2) + 0.5 * 0 - c - H$

Trade Payoff War for $P_2 = 0.5 * (W_2 + b * W_1) + 0.5 * 0 - c - H$

Therefore, the payoff matrix for the second stage of the game is represented in Table 3.1.2 which only accounts for the costs and benefits received in the second stage (without accounting for H).

Table 3.1.2: Payoff Matrix of the strategies in the second stage of the Basic Model.

Player 1 / Player 2	Trade	War
Trade	$W_1 + b * 0.5 * T$, $W_2 + b * 0.5 * T$	$Pr_{wa} * (W_1 + b * W_2) - c$, $Pr_{wd} * (W_2 + b * W_1) - c$
War	$Pr_{wd} * (W_1 + b * W_2) - c$ $Pr_{wa} * (W_2 + b * W_1) - c$	$0.5 * (W_1 + b * W_2) - c$, $0.5 * (W_2 + b * W_1) - c$

***Note: Payoffs for player 1 are shown first and each payoff is separated by comma

In conclusion, I will provide a brief overview of the timing of the game

1. The game starts with two players P_1 and P_2
2. Each player simultaneously chooses a high interdependent or a low interdependent relationship.
3. If both players choose a high interdependent relationship, then both countries have a highly interdependent relationship with each other and pay cost H
4. However, if either player chooses a low interdependent relationship, regardless of the decision of the other player, both countries will have a low interdependent relationship and pay nothing.
5. Following that, each player chooses to go to war or to trade.

3.2 Basic Model Analysis

In this part, the model would be analysed using the payoffs from the game to determine how each choice affects both players in order to provide fundamental insights. As the model has two stages, the game will be solved using backward induction, and therefore we will start in the second stage of the game.

Second Stage of Basic Model

Table 3.2.1: Payoff Matrix of the strategies in the second stage of the Basic Model.

Player 1 / **Player 2**	Trade	War
Trade	$W_1 + b * 0.5 * T$, $W_2 + b * 0.5 * T$	$Pr_{wa} * (W_1 + b * W_2) - c$, $Pr_{wd} * (W_2 + b * W_1) - c$
War	$Pr_{wd} * (W_1 + b * W_2) - c$ $Pr_{wa} * (W_2 + b * W_1) - c$	$0.5 * (W_1 + b * W_2) - c$, $0.5 * (W_2 + b * W_1) - c$

***Note: Payoffs for player 1 are shown first and each payoff is separated by comma

Table 3.1.2 is repeated here in Table 3.2.1, because it will be used to solve the second stage subgame. Using Table 3.2.1, if player 1 chooses war, then player 2 also chooses war. If player 2 chooses war, then player 1 also chooses war. This is because if one player chooses war, it is always a dominant strategy to choose war given that the odds of winning are higher, hence payoffs are higher. Therefore (War, War) is a subgame equilibrium in this model.

This conclusion follows from the model because the benefit of interdependence affects both trade and war. Additionally, the assumption that players are only allowed to war in a highly interdependent relationship allows this result to occur. This conclusion could be seen as a country grooming the other country for war and there is historical evidence of this. For example, the economic relationship between Britain and modern day Nigeria started out as a trading relationship in the 1820s. By the mid nineteenth century, the British began conquering parts of Nigeria and establishing them as British colonies. A main reason for this was control the trade of the resources from Nigeria. This is an example of the period of Western colonization whereby countries were groomed in order to be prepared for colonization. However, this example also shows evidence of different objectives when joining an interdependent relationship. In this case, the presence of an aggressive country, Britain and the presence of a peaceful country, Nigeria. It is interesting to question if Nigeria knew the type of

country Britain was, and whether given that Nigeria would still have allowed for an interdependent relationship? This question would be explored further in Section 4.2.

There are four main assumptions for War to be a Nash Equilibrium. Firstly, the only "punishment" for war is the cost of war. This in reality does not hold because there could be outside costs of war such as sanctions which would be explored in an extension in Section 4.1. Additionally, the other country could be a valued ally or an important ally to one of the country's allies. Secondly, there is an assumption that government body is always in agreement. This in reality does not hold because there could be different political parties with different perspective. Thirdly, there is an assumption that countries can only war in a highly interdependent relationship. This assumption does not hold in reality given that countries can raid other countries without proposing trade agreements or without being interdependent with those countries. Fourthly, an important assumption is the presence of the first mover advantage. This assumption exists in reality because by being the attacker, a country can start with their opponents weakest defence. On the other hand, when a country does not attack first, their opponent is able to turn the war into a sequential game in which the defending country can only respond as opposed to acting first. However, this assumption does not always hold because although countries are not going to war, they are still prepared with accurate defences. Additionally countries also have warning mechanisms that let them know when other countries are beginning a war with them such as spies, missile warning systems, etc.

Given that (War, Trade) and (Trade, War) are dominated strategies, it is important to test if (Trade, Trade) is a subgame equilibrium. If Player 1 chooses Trade, player 2 will only choose trade if the payoff from Trade is higher than that of War. Hence if:

$$W_2 + b * 0.5 * T > Pr_{wa} * (W_2 + b * W_1) - c$$

$$W_2 + b * 0.5 * T + c - Pr_{wa} * (W_2 + b * W_1) > 0 \ldots eq(1)$$

When eq(1) is greater than 0, player 2 will choose Trade. W_2 is always greater than 0, b is greater than 1 and c is greater than 1. ($W_2 + b*0.5*T + c$) is always positive, therefore there are 2 ways eq(1) is greater than 0:

$$Pr_{wa} * (W_2 + b * W_1) \leq 0$$
$$Pr_{wa} * (W_2 + b * W_1) < W_2 + b * 0.5 * T + c \ldots ConditionA$$

The first equation is never true in this model, because Pr_{wa}, W_2, b and W_1 are greater than 0. Therefore the first condition can never hold as it will always be positive and non-zero.

The second equation (condition A) makes sense intuitively, as it means if the benefit from trade plus the cost of war are greater than the benefit of war, then player 2 will rather trade. In essence, if the

trade surplus is really high then each player will be less likely to war as there is more to gain from trade. Similarly, if the cost of war is very high, then the player is less likely to go to war.

Proposition 1: A higher trade surplus and a higher cost of war increases the incentive to trade and decreases the incentive to go to war.

The second condition can be rearranged to:

$$W_2 * (1 - Pr_{wa}) + c > b * (Pr_{wa} * W_1 - 0.5 * T) \dots eq(2)$$

The LHS of eq(2) is always positive and non-zero, so if

$$b * (Pr_{wa} * W_1 - 0.5 * T) \leq 0$$

then eq(2) is true

This occurs when :

$$Pr_{wa} < 0.5 * T / W_1 \dots eq(3)$$

Eq (3) means that the probability of winning the war has to be less than the opportunity cost of Trade. Therefore, if the probability of winning the war is less than the opportunity cost of trade, then trading is more attractive to either player.

Eq(2) can also be rearranged as:

$$W_2 * (1 - Pr_{wa}) + b * 0.5 + T > b * Pr_{wa} * W_1 - c \dots eq(4)$$

The LHS of eq(4) is always positive and non-zero due to the conditions of the parameters. For eq(4) to hold then the RHS must be less than or equal to 0.

$$b * Pr_{wa} * W_1 - c \leq 0$$

This happens when:

$$b < c / (Pr_{wa} * W_1) \dots eq(5)$$

Eq(5) means that the benefit of interdependence has to be less than the relative difference between the cost of war and the benefit of war. The higher the relative difference between the cost of war and the benefit, the higher the benefits of interdependence would have to be to make war more beneficial. This is because b affects the benefit of war while interdependent but also affects the benefits of trading while interdependent.

For player 2 to choose trade equation 2 an be rearranged to give condition A which is expressed in terms of b:

$$b < \frac{W_2 + c}{Pr_{wa} * W_1 - 0.5T} \ldots ConditionA$$

If condition A is met, player 2 chooses trade.

The threshold value in this case is:

$$b = \frac{W_2 + c}{Pr_{wa} * W_1 - 0.5T}$$

The threshold value is the value at which a player is indifferent between the two choices.

In order to analyse the threshold value, derivatives will be used.

$$db/dc = \frac{1}{W_1 * Pr_{wa} - 0.5T}$$

Through the above derivative it is observable that as the cost of war increases, the benefit of interdependence increases. This in turn makes intuitive sense because if war is costly then it is more beneficial to trade. Additionally, although b affects both the benefits of war and trade, a much costlier war would reduce the overall profit even when the benefits of interdependence are high. In that case, it would be more beneficial for countries to trade.

$$db/dW_2 = \frac{1}{W_1 * Pr_{wa} - 0.5T}$$

Similarly, from the above derivative a higher domestic production increases the benefit of interdependence. This is because countries with a high production often have more good variety, technology advancement and more that would benefit their trading partners, thereby increasing the benefit of interdependence.

$$db/dT = \frac{W_2 + c}{2(W_1 * Pr_{wa} - 0.5T)^2}$$

Additionally, the above derivative portrays that a higher trade volume increases the benefit of interdependence. This is not a surprising result considering that as two countries increase their trade volume, their economies enjoy increasing mutual benefits due to the economies of scale as proposed in this model.

$$db/dW_1 = -\frac{Pr_{wd} * (W_2 + c)}{(W_1 * Pr_{wa} - 0.5T)^2}$$

Alternatively, a higher foreign production decreases the benefit of interdependence. This result is surprising but can be explained when considering that if another country has a higher production,

there is more of an incentive to plunder their resources. Moreover, given that the outcome of war is uncertain the benefit of interdependence are less than in a trading relationship.

For player 1 to choose trade a similar condition can be found:

$$b < (W_1 + c)/(Pr_{wa} * W_2 – 0.5T) \ldots ConditionB$$

If both Condition A is met for player 2 and Condition B is met for player 1 then then (Trade, Trade) is a Nash Equilibrium.

First Stage of Basic Model

Now that the outcomes from the second stage of the model are known, the outcomes from the first stage of the model can be understood. Based on the first stage there are three possible outcomes in which the first player's outcome is portrayed first:

Both players choose Low Interdependence and outcome for each player:

$$(W_1, W_2)$$

Both players choose High Interdependence and War, outcome for each player:

$$(0.5 * (W_1 + b * W_2) - c - H, 0.5 * (W_2 + b * W_1) - c - H)$$

Both players choose High Interdependence and Trade, outcome for each player is:

$$(W_1 + b * 0.5 * T - H, W_2 + b * 0.5 * T - H)$$

Based on the second stage, we know when (War, War) is a NE and when (Trade, Trade) is a NE. The inclusion of the interdependence cost, *H* does not change this as it is the same for both outcomes. Therefore, it is important to find under which conditions (Low Interdependence and no relationship) is a NE, (High interdependence and War) is a NE and (High interdependence and Trade) is a NE.

Assuming (war, war) is the chosen strategy for the second stage, player 2 will prefer (High Interdependence, War, War) when the payoff is higher than that of (Low Interdependence, no relationship)

Therefore when:

$$0.5 * (W_2 + b * W_1) - c - H > W_2 \ldots eq(5)$$

$$b > (c + H + 0.5 * W_2)/W_1 \ldots ConditionC$$

If condition C holds, Player 2 will prefer (High Interdependence, War, War)

By rearranging the above equation, insights can be gotten from the model

$$-0.5 * W_2 + (0.5 * b * W_1 - H) - c > 0 \ldots eq(6)$$

Therefore increasing the cost of high interdependence, increases the incentive to have low interdependence. This is because from eq(6) it is evident H and c reduces the equation. This in turn makes sense because if the costs to high interdependence are increased such as increasing the coordination time for trade agreements, then countries are more likely to have no trade. This is similar to the effect of the cost of war because by increasing c, then players are more likely to have no relationship. By increasing the cost of war, the incentive to have low interdependence also increases.

Another important note is that increasing the domestic production of one's country increases the incentive to have no trade. This is because the higher domestic production volume, the more self-sufficient a country can be on its own without a relationship.

Proposition 3 : Increasing the domestic production of the players own country, increases the incentive to have no trade however increasing the domestic production of the other player's country increases the incentive to have an interdependent relationship.

On the other hand, increasing the domestic production of the other country increases the incentive to have a highly interdependent relationship. This is because through that relationship, the country can benefit by plundering those resources. Consequently, increasing the domestic production of the other country increases the incentive for war.

If (trade, trade) is the chosen strategy for the second stage. Player 2 will prefer (High Interdependence, Trade, Trade) when the payoff is higher than that of (Low Interdependence, no relationship).

$$W_2 + b * 0.5 * T - H > W_2$$

This equation can be rearranged to give Condition D

$$b > H/(0.5T) \ldots ConditionD$$

Condition D means trading in a highly interdependent relationship would be a Nash Equilibrium when the benefit of interdependence is greater than the relative difference between the cost of interdependence and the benefit of trade. This in turn makes sense because if condition D does not hold then the benefit of trading while highly interdependent will be lower than the cost of high interdependence.

I will now summarize the Nash Equilibriums in this model and under which conditions they hold:

1. High Interdependence ,Trade:

Condition for Player 1: $H/(0.5T) < b < c/(Pr_{wa} * W_2)$

Condition for Player 2: $H/(0.5T) < b < c/(Pr_{wa} * W_1)$

2. High Interdependence ,War:

Condition for Player 1: $(c + H + 0.5 * W_1)/W_2 < b < (W_1 + c)/(Pr_{wa} * W_2 - 0.5T)$

Condition for Player 2: $(c + H + 0.5 * W_2)/W_1 < b < (W_2 + c)/(Pr_{wa} * W_1 - 0.5T)$

3. (Low Interdependence, No Relationship): for both players the lowest of either condition has to be met:

Condition for Player 1: $b < H/(0.5T)$ and $b < c + H + 0.5 * W_1$

Condition for Player 2: $b < H/(0.5T)$ and $b < c + H + 0.5 * W_2$

Therefore, in this game there are three pure Nash Equilibria:

1. Both countries have war in a highly interdependent relationship
2. Both countries have trade in a highly interdependent relationship
3. Both countries have no relationship in a low interdependent relationship

It is also important to consider the mixed strategy subgame equilibria in the second stage of the model. Suppose player 2 will war with probability *q* and trade with probability *1-q*, then player 1 will have payoffs of:

If Player 1 wars: $q * (0.5 * (W_1 + b * W_2) - c) + (1 - q) * (Pr_{wa} * (W_1 + b * W_2) - c)$

If Player 1 trades : $q * Pr_{wd} * (W_1 + b * W_2) + (1 - q) * (W_1 + b * 0.5 * T) - c$

Player 1 will war when:

$$q * (0.5 * (W_1 + b * W_2) - c) + (1 - q) * (Pr_{wa} * (W_1 + b * W_2) - c) > q * (Pr_{wd} * (W_1 + b * W_2) - c) + (1 - q) * (W_1 + b * 0.5T)$$

For player 2 to maximize his payoff, he needs to minimize the payoff for player 1which can be done by equating both sides:

$$q = (-(Pr_{wa} * (W_1 + b * W_2) - c) + (W_1 + b * 0.5 * T))/(0.5 * (W_1 + b * W_2)) + W_1 + b * 0.5 * T$$

$$* Pr_{wa} * (W_1 + b * W_2) - Pr_{wd} * (W_1 + b * W_2) - 3c)$$

$$1 - q = (0.5 * (W_1 + b * W_2) - Pr_{wd} * (W_1 + b * W_2) - 2c)/(0.5 * (W_1 + b * W_2) + W_1 + b * 0.5T$$
$$- Pr_{wa} * (W_1 + b * W_2) - Pr_{wd} * (W_1 + b * W_2) - 3c)$$

Therefore player 2 should war with q probability and trade with 1-q probability. This is the mixed strategy for player 2.

Similar probabilities can be found for player 1.

Suppose player 1 goes to war with probability r and trade with probability 1-r , then the payoff is:

If player 2 wars: $r * (0.5 * (W_1 + b * W_2) - c) + (1 - r) * (Pr_{wd} * (W_1 + b * W_2) - c)$

If player 2 trades: $r * (Pr_{wa} * (W_1 + b * W_2) - c) + (1 - r) * (W_1 + b * 0.5 * T)$

For player 1 to maximize their payoff, the two above equations should be equated

$$r * (0.5 * (W_1 + b * W_2) - c) + (1 - r) * (Pr_{wd} * (W_1 + b * W_2) - c) = r * (Pr_{wa} * (W_1 + b * W_2) - c) + (1 - r) * (W_1 + b * 0.5 * T)$$

$$r = (W_1 + b * 0.5 * T - Pr_{wd} * (W_1 + b * W_2) - c) / (0.5 * (W_1 + b * W_2) + W_1 + b * 0.5T - Pr_{wd} * (W_1 + b * W_2) - Pr_{wa} * (W_1 + b * W_2) - 3c)$$

$$1 - r = (0.5 * (W_1 + b * W_2) - Pr_{wa} * (W_1 + b * W_2) - 2c) / (0.5 * (W_1 + b * W_2) + W_1 + b * 0.5 * T - Pr_{wd} * (W_1 + b * W_2) - Pr_{wa} * (W_1 + b * W_2) - 3c)$$

Therefore the mixed strategy is:

Player 1: $r * W$ and $(1 - r) * T$

Player 2: $q * W$ and $(1 - q) * T$

Where *W* is war and *T* is trade.

4. Extensions

4.1 Inclusion of Outside Incentives

So far the model has looked at both countries in isolation, however realistically there are always outside countries who can influence decisions of either player. For example, either player could have other trading partners, other enemy states or allies. Therefore, this extension would model the inclusion of outside incentives. The outside incentives considered in this model are sanctions and foreign aid. Sanctions can be defined as “a punitive measure or action resulting from failure to comply with the law”. Foreign aid can be defined as “assistance transferred from one country to another in the form of a gift, grant or loan”.

Currently, countries follow international law and respect state sovereignty. In this model, the only motivation for choosing war is the capture of resources. This motivation does not respect state sovereignty, so outside countries punish it with the use of sanctions Consequently, in this model if either or both players choose to go to war, then that country faces a financial sanction, *fs* regardless of whether that player wins or loses. Alternatively, if a country is defending itself in war this is respecting state sovereignty. The outside world respects that a country has to protect its sovereignty and aid it in doing so. As a result, if a player does not choose war when the other player chooses war, then that player receives foreign aid, *fa* regardless of the war outcome. The foreign aid in this model is

always in form of a financial grant that is not paid back. The foreign aid received is always less than the cost of war and less than domestic production in absence of trade. This is based on the assumption that outside countries cannot fully mitigate the cost of war for another country, because those countries also have their own domestic matters. Especially considering, that the financial aid is not a loan and will not be paid back. The model for this extension would follow the same form as the basic model with modifications for the inclusion of the outside incentives as portrayed in Table 4.1.1

Table 4.1.1: Payoff Matrix of the strategies in the Inclusion of Outside Incentives Model for the second stage.

Player 1 / **Player 2**	Trade	War
Trade	$W_1 + b * 0.5 * T, W_2 + b * 0.5 * T$	$Pr_{wa} * (W_1 + b * W_2) - c - fs,$ $Pr_{wd} * (W_2 + b * W_1) - c + fa$
War	$Pr_{wd} * (W_1 + b * W_2) - c + fa,$ $Pr_{wa} * (W_2 + b * W_1) - c - fs$	$0.5 * (W_1 + b * W_2) - c - fs,$ $0.5 * (W_2 + b * W_1) - c - fs$

***Note: Payoffs for player 1 are shown first and each payoff is separated by comma

If player 1 chooses trade, player 2 will choose trade when:

$$W_2 + b * 0.5 * T > Pr_{wa} * (W_2 + b * W_1) - c - fs$$
$$fs > Pr_{wa} * W_2 - W_2 - c - b * (0.5T - W_1) \ldots ConditionH$$

Focusing more on Condition H, the influence of fs on the choice to trade when the other player trade can be examined. Firstly, the threshold value is:

$$fs = Pr_{wa} * W_2 - W_2 - c - b * (0.5T - W_1)$$

The threshold value can be analysed by taking its derivative with respect to certain values:

By taking the derivative of *fs* with respect to W_2:

$$dfs/dW_2 = Pr_{wa} - 1$$

It is evident that *fs* is decreasing in W_2 given that Pr_{wa} is less than 1. Therefore, by increasing the domestic production of a country, the financial sanction required to promote trade is reduced. This is because with a high domestic production, a country has more to lose from war, consequently a lessened financial sanction is required to deter war.

By taking the derivative of *fs* with respect to *c*:

$$dfs/dc = -1$$

It is evident that *fs* is decreasing in *c*, increasing the cost of war also reduces the required financial sanction to deter war. This makes sense with the model, as in the basic model it was proven that a high cost of war reduces the incentive for war. Therefore, with a high cost of war, a reduced financial sanction is required to deter war.

By taking the derivative of *fs* with respect to *b*:

$$dfs/db = -(0.5T - W_1)$$

It is evident that *fs* is decreasing in *b* when $0.5T$ is greater than W_1 and *fs* is increasing in *b* when W_1 is greater than $0.5T$. This means that the effect on *b* depends on the difference between the gains from the share of trade and the domestic production of the other country. As a result, if the county's gains from trade are higher than the domestic production of the other country then a reduced financial sanction is required as the incentive to trade is higher. However, if the domestic production of the other country is higher than the country's gains from trade, then a higher financial sanction is required, because the incentive to go to war is higher.

Using Table 4.1.1, If player 1 chooses war, then player 2 might no longer choose war. This is because for player 2 to choose war:

$$0.5 * (W_2 + b * W_1) - c - fs > Pr_{wd} * (W_2 + b * W_1) - c + fa$$

Therefore, for player 2 to choose war

$$fa < 0.5 * (W_2 + b * W_1) - fs - Pr_{wd} * (W_2 + b * W_1) \ldots eq(7))$$

The thereshold value for *fa* is:

$$fa = 0.5 * (W_2 + b * W_1) - fs - Pr_{wd} * (W_2 + b * W_1) \ldots eq(8))$$

As done previously, the derivatives of *fa* with respect to certain values will be used to understand their effect.

$$dfa/dfs = -1$$

From the above, it is evident that by increasing financial sanction, the required financial aid can be reduced. This is because financial sanctions deter the war, so if countries do not have enough capital for financial aid, they can increase the financial sanctions instead. Similarly if the equation is rearranged it is also evident that by increasing the financial aid, the required financial sanction can

also be reduced. Through this it is evident that the financial aid and financial sanctions can be used together to prevent war.

$$dfa/dW_2 = 0.5 - Pr_{wd}$$

From the above, it is evident that financial aid is increasing in W_2 given that Pr_{wd} is less than 0.5. Therefore, with a higher domestic production, a higher financial aid is required. This is because, countries with a higher domestic production have more to lose from the first mover advantage of war. In order to provide sufficient incentive for those countries, a higher financial aid is required.

$$dfa/db = 0.5W_1 - Pr_{wd}W_1$$

From the above, it is evident that financial aid is increasing in W_1. This in turn makes intuitive sense because if the domestic production of the other country is higher, a much larger incentive in terms of financial aid is required to prevent the country from going to war.

Therefore if player 1 chooses war then player 2 will choose war when:

$$fs < 0.5 * (W_2 + b * W_1) - fa - Pr_{wd} * (W_2 + b * W_1) \dots (ConditionI)$$

As both players have similar payoffs, similar conditions can be found for player 1

Player 1 will choose trade when player 2 chooses trade provided the below condition is met:

$$fs > Pr_{wa} * W_1 - W_1 - c - b * (0.5T - W_2) \dots ConditionJ$$

Player 1 will choose war when player 2 chooses war provided the below condition is met:

$$fs < 0.5 * (W_1 + b * W_2) - fa - Pr_{wd} * (W_1 + b * W_2) \dots (ConditionK)$$

Therefore in the second stage of the game, there are four pure Nash equilibria:

1. Both countries will trade if Condition J is met for Player 1 and Condition H for Player 2:

$$fs > Pr_{wa} * W_1 - W_1 - c - b * (0.5T - W_2) \dots ConditionJ$$

$$fs > Pr_{wa} * W_2 - W_2 - c - b * (0.5T - W_1) \dots ConditionH$$

2. Both countries will go to war if Condition K is met for player 1 and Condition I for player 2:

$$fs < 0.5 * (W_1 + b * W_2) - fa - Pr_{wd} * (W_1 + b * W_2) \dots (ConditionK)$$

$$fs < 0.5 * (W_2 + b * W_1) - fa - Pr_{wd} * (W_2 + b * W_1) \dots (ConditionI)$$

3. Player 1 chooses trade and player 2 chooses war when Condition M is met for player 1 and Condition L is met for player 2:

$$fs > 0.5 * (W_1 + b * W_2) - fa - Pr_{wd} * (W_1 + b * W_2) \dots ConditionM$$

$$fs < Pr_{wa} * W_2 - W_2 - c - b * (0.5T - W_1) \dots ConditionL$$

4. Player 1 chooses war and player 2 chooses trade when Condition M is met for Player 1 and Condition O for player 2:

$$fs < Pr_{wa} * W_1 - W_1 - c - b * (0.5T - W_2) \ldots ConditionN$$
$$fs > 0.5 * (W_2 + b * W_1) - fa - Pr_{wd} * (W_2 + b * W_1) \ldots ConditionO$$

By the inclusion of outside incentives it is no longer a dominant strategy to choose war, because the payoffs from war are distorted. Consequently, the (War, War) equilibrium can be removed provided certain conditions are met. In comparison to the basic model game, with outside incentives it is much harder for countries to go to war unless the benefits of interdependence are very high. Therefore, by the inclusion of financial sanctions and financial aid, a country can be motivated to choose trade even if the other country chooses war, provided the financial sanctions erode the gain in the probability of winning, all other things equal. With the inclusion of financial sanctions and financial aid, the risk of war during interdependence is reduced. Additionally, it is now a Nash Equilibria to choose trade when the other person chooses war, which is on account of the influence of the financial aid. Therefore, international law reduces the cost of interdependence by reducing the risk of war.

4.2 Inclusion of Players with Different Objectives

Thus far, the interdependence has focused on the mechanism through which interdependence can affect the possibility of war. The addition of different players with different objectives allows to examine how interdependence changes when players want it for different reasons. Therefore there will be an inclusion two types of players *p*, peaceful and *w*, warlike and this game will have 2 players. Peaceful countries always trade in a highly interdependent relationship and warlike countries always go to war in a highly interdependent relationship. One player has a known type which is peaceful. On the other hand, the second player has an unknown type which is peaceful with probability p_1 and warlike with probability $1\text{-}p_1$. Both players know the type of the peaceful player, however the type of the unknown player is only known by the unknown player. The player with the known type however knows the probability distribution of the type of the other player. This game will be modelled using the British colonization of Nigeria. As a result, Nigeria will be the peaceful country with the known type, (player 1) and British will be the country with the unknown type, (player 2). The model in this game will follow the same guidelines as the basic model in Section 3.2 with some modifications. The model will additionally have the same payoffs for the second stage. However, the model will have a different first stage. In the first stage of the model, Britain has the opportunity to offer a trade agreement to Nigeria or raid Nigeria. In the first stage, peaceful countries always offer trade agreements however, warlike countries can raid in the first stage or they can offer a trade agreement and war in the second stage. Additionally, the payoff from raid is less than the payoff from war because player 1 has not had the opportunity to pair the units of their country with the units of player 2. In other words, the benefit of interdependence has not been cultivated. In the second stage of the

model, Nigeria can decide to have high interdependence with Britain which is signing the trade agreement, or to have low interdependence with Britain which is not signing the trade agreement.

Similar to the basic model, domestic production for both countries is exogenous and represented by W_1 and W_2 for Nigeria and Britain respectively. Additionally D_1 and D_2 for both countries are equal to 0.5, hence both countries share the income from trade equally. Trade volume is also exogenous and is modelled by parameter, T. There is no interdependence cost in this game because the cost of interdependence here is that Nigeria is unsure of Britain's objectives. The game starts with player 1 approaching player 2 with a highly interdependent trading contract or raiding Nigeria. If Britain raids Nigeria, the game ends in the first stage. If player 1 offers a trade agreement, player 2 decides on a high interdependent or low interdependent relationship based on their knowledge of the probability distribution of the type of player 1. If player 2 choose a low interdependent relationship, then both countries have no relationship and their income is just their domestic production, regardless of the type of player. If player 2 chooses a high interdependent relationship, when both countries are peaceful, then they will trade. If player 2 chooses a high interdependent relationship, when player 1 is warful, then both countries will have war with player 1 having the first mover advantage. This is based on the assumption that when a peaceful country chooses a highly interdependent relationship, it is always for trade, therefore if player 1 is warlike, player 2 will not be as prepared for war.

Therefore, there are five different possible outcomes in this scenario:

1. Both players are peaceful and have high interdependent trading relationship
2. Both players are peaceful and have a low interdependent relationship
3. Player 1 is warlike and both countries have war
4. Player 1 is warlike and both countries have a low interdependent relationship
5. Player 1 is warlike and raids player 2.

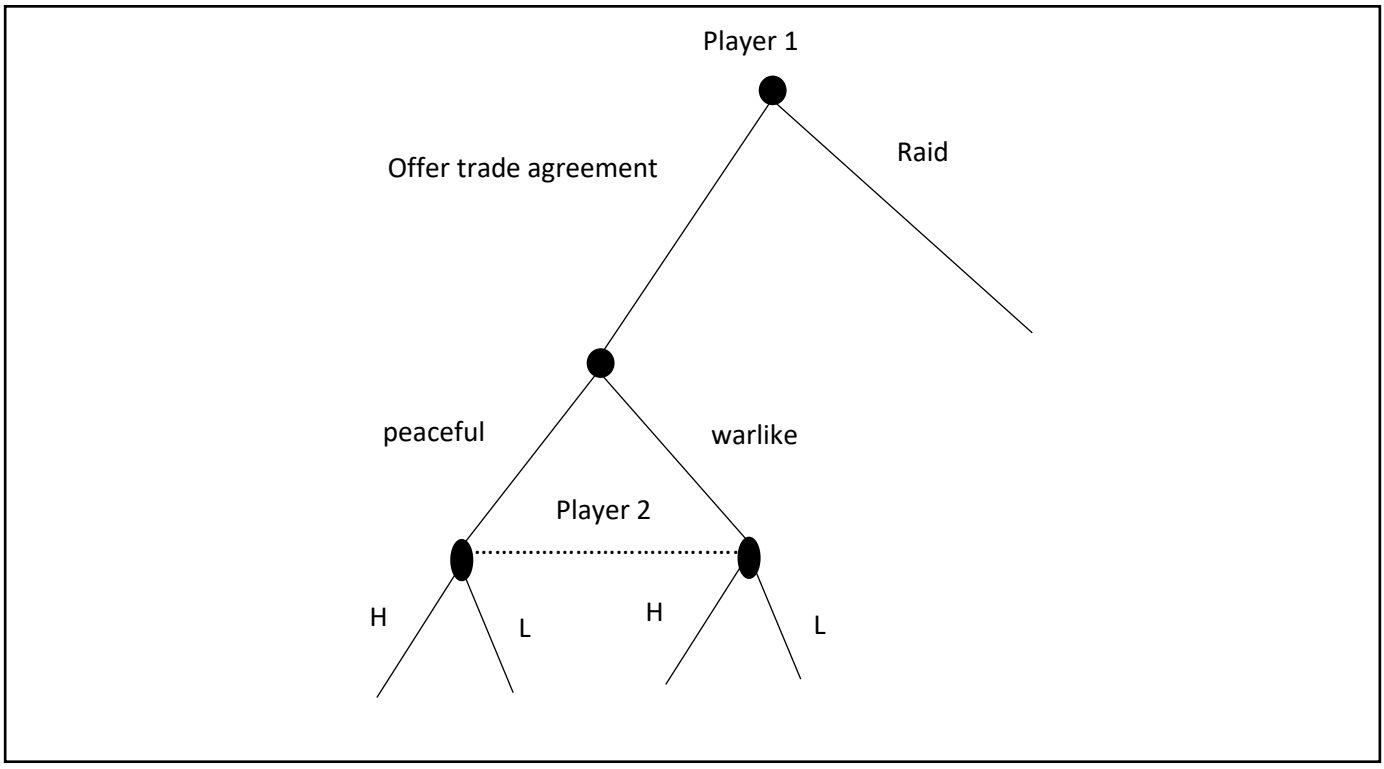

Fig 4.2 Tree Representation of Game with the Inclusion of players with Different Objectives.

Fig 4.2 provides a visual representation of the proposed choices of player 1 and player 2 in which p and w are peaceful and warlike. Additionally H and L are high interdependence and low interdependence with the dotted line representing that player 2 is not aware of which decision point he is at when he makes a decision.

Second Stage of Model

In order to understand what the response of player 2 would be, it is important to calculate the expected payoffs from each choice in the second stage.

Firstly, if player 1 is peaceful and player 2 chooses high interdependence then the payoff is:

Payoff Player 1: $W_1 + b * 0.5T$

Payoff Player 2: $W_2 + b * 0.5T$

Conversely, if player 1 is warlike and player 2 chooses high interdependence then the payoff is:

Payoff Player 1: $Pr_{wa} * (W_1 - b * W_2) - c$

Payoff Player 2: $Pr_{wd} * (W_2 - b * W_1) - c$

Therefore the expected value for each player will then be:

$$EV_1 = p_1 * (W_1 + b * 0.5T) + (1 - p_1) * (Pr_{wa} * (W_1 - b * W_2) - c)$$

$$EV_2 = p_1 * (W_2 + b * 0.5T) + (1 - p_1) * (Pr_{wd} * (W_2 - b * W_1) - c)$$

Secondly, if player 1 is peaceful or warlike and player 2 chooses low interdependence then the payoff is:

Payoff Player 1: W_1

Payoff Player 2: W_2

The expected value for each player will then be:

$$EV_1 = W_1$$

$$EV_2 = W_2$$

Therefore, player 2 will choose a highly interdependent relationship when the payoff from high interdependence is greater than the payoff from low interdependence:

$$p_1 * (W_2 + b * 0.5T) + (1 - p_1) * (Pr_{wd} * (W_2 - b * W_1) - c) > W_2$$

This happens when:

$$p_1 > \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * (W_2 - b * W_1) - c)} \quad \dots ConditionP$$

The threshold value occurs at:

$$p_1 = \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * (W_2 - b * W_1) - c)}$$

Through derivatives, it is possible to analyse how each parameter affects p_1

$$dp_1/dW_2 = -\frac{2(Pr_{wd} - 1)(bT + 4c)}{W_2(2Pr_{wd} - 2) - 2Pr_{wd} * b * W_1 - bT - 2c^2}$$

Firstly, with W_2, it is evident from the above derivative than an increase in W_2 decreases p_1. This in turn makes sense because p_1 is the probability of peaceful nature. Therefore, the higher the domestic production of a country, the more likely the other country is warlike. This follows from conclusions in the models studied in section 3. A country with a higher domestic production has more resources to be plundered from with war. This is also evident in the British-Nigeria relationship, given that Nigeria had a lot of natural resources which Britain wanted access to such as: tin, cocoa and eventually crude oil. (Graham, 2009).

$$dp_1/dW_2 = \frac{2(Pr_{wd} * b)(bT + 4c)}{(W_1 * b * 2Pr_{wd} + (2 - 2Pr_{wd}) * W_2 + bT + 2c)^2}$$

However, from the above derivative with W_1 it is evident than an increase in the other country's production increases their probability of being peaceful. This also follows from previous conclusions

in the models of section 3 because, a country with a higher production has more to lose from war. As a result, that country would be less likely to go to war and instead want a trading relationship. This conclusion is based on the assumption that a country's production does not affect their probability of winning wars. This might not hold in a real world situation because countries with higher productions tend to have higher incomes, better technology which also affect war capacity.

$$dp_1/dc = -\frac{2(4Pr_{wd} * b * W_1 + (4 - 4Pr_{wd}) * W_1 + bT)}{(2c + 2Pr_{wd} * b * W_2 + W_2(2 - 2Pr_{wd}) + bT)^2}$$

From the above derivative, a higher cost of war increases the likelihood of the other country being warlike. This is because *c* in this case represents the cost of war for player 2 as the cost of war for player 1 does not come into the equation in this scenario. As a result, if a country has a higher cost of war, the other country is more likely to be warlike, perhaps because that country has a reduced war cost. Additionally, it could also be that the other country is aware the war cost might diminish the country's resources.

$$dp_1/db = \frac{2(4Pr_{wd} * c * W_1 + (Pr_{wd} - 1)T * W_2) + cT}{(2Pr_{wd} * W_1 + T)b + W_2(2 - 2Pr_{wd} + 2c)^2}$$

Alternatively, from the above derivative a higher interdependence benefit increases the probability that the other country is peaceful. This is an interesting conclusion from this model because the benefits of interdependence affects the benefits of trade and also the benefits of war. However, with this model it is portrayed that a higher interdependence benefit incentivizes the other country to be peaceful as opposed to warlike. For example, neighbouring countries where one country has an excess supply of tin, and the other has an excess demand of tin could have more to gain from trade instead of war for the plundering of those resources.

Therefore both countries will have a highly interdependent relationship when:

$$p_1 > \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * (W_2 - b * W_1) - c)}$$

And both countries will have a low interdependent relationship when:

$$p_1 < \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * (W_2 - b * W_1) - c)}$$

First Stage of Model

In order to solve the model, it is important to determine the payoffs from raid for a warlike country.

A raid is "a sudden or surprise attack on an enemy using military forces" (Oxford University Press, 1989). Given the definition of raid, the payoff from a raid is based on the strength of player 1 and also

the strength of the defence mechanisms of player 2. This will be modelled by Pr_{raid} which is always less than 0.5 to represent the assumption that the payoff from raid is less than from war. The Pr_{raid} is also always greater than 0, because raids are surprise attacks, therefore player 1 will always gain something. Additionally there is a cost of raid, c_r which is also less than the cost of war given that raids are smaller attacks. Therefore the payoff from raid for each player is:

Payoff Raid for Player 1: $Pr_{raid} * W_2 - c_r$

Payoff Raid for Player 2: $-Pr_{raid} * W_2$

If a country is peaceful they always offer a trade agreement. However if a country is warlike, they will raid when the payoff from raid is greater than the payoff from war:

$$Pr_{raid} * W_2 - c_r \quad > \quad Pr_{wa} * (W_1 - b * W_2) - c$$

This happens when:

$$Pr_{raid} > \frac{Pr_{wa} * W_1 + c_r - c}{W_2} - Pr_{wa} * b \ldots ConditionR$$

The threshold value is:

$$Pr_{raid} = \frac{Pr_{wa} * W_1 + c_r - c}{W_2} - Pr_{wa} * b$$

For example, $c_r - c$ is the difference between the cost of raid and the cost of war which is always less than 0. It is evident that the closer this value is to 0, the higher the probability of raid. This means that the closer the cost of raid is to the cost of war, player 2 would be more likely to raid. This makes sense because in a raid player 2 will always gain, whereas in a war player 2 has the chance to lose. Therefore, the closer the cost of raiding is to the cost of war it is more beneficial to raid.

By finding derivatives it is possible to see how other terms affect Pr_{raid}.

$$dPr_{raid}/db = -Pr_{wa}$$

From the above derivative, the benefit of interdependence decreases the probability of raiding because as b increases, it is more beneficial to war than raid. This is also in line with previous conclusions given that the benefit of interdependence positively affects the incentive for war.

$$dPr_{raid}/dW_2 = -\frac{Pr_{wa} + W_1 - c_r - c}{(W_2)^2}$$

Similarly, from the above derivative as the production of the foreign country, W_2 increases it is more advantageous to have war than to raid because the payoffs are higher from war than raid.

$$dPr_{raid}/dW_1 = \frac{Pr_{wa}}{W_2}$$

From the above derivative, as the domestic production of a country increases, this in turn increases the probability of raid. This is for the reason that, a country with a higher domestic production is more self-sufficient, therefore they would require the higher payoff from war with a foreign country less than a country with a lower domestic production.

$$dPr_{raid}/dPrwa = \frac{W_1}{W_2} - b$$

The above derivative portrays that Pr_{wa} has a negative effect on the probability of raiding when the benefit of interdependence is higher than the relative difference between domestic and foreign production. This makes sense intuitively because if the benefit of interdependence is higher than the relative difference between domestic and foreign production, it is more advantageous to war for a warlike country. However, if the relative difference between domestic and foreign production is higher than the benefit of interdependence it is more advantageous to raid, for a warlike country.

Therefore in this game there are 4 possible pure Nash equilibria:

1. Britain raids Nigeria which happens when Condition R is met for player 1 and no condition has to be met for Player 2

   $$Pr_{raid} > \frac{Pr_{wa} * W_1 + c_r - c}{W_2} - Pr_{wa} * b \ldots ConditionR$$

2. Britain and Nigeria trade in a highly interdependent relationship which happens when:
   Condition Player 1: Player 1 is type *p*
   Condition Player2: $p_1 > \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * (W_2 - b * W_1) - c)}$

3. Britain and Nigeria have a low interdependent relationship which happens when:
   Condition Player 1: Either player 1 is type p or player 1 is type w and Condition S is met

   $$Pr_{raid} < \frac{Pr_{wa} * W_1 + c_r - c}{W_2} - Pr_{wa} * b \ldots ConditionS$$

   Condition Player 2: Condition Q is met

   $$p_1 < \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * W_2 - b * W_1 - c)} \ldots ConditionQ$$

4. Britain and Nigeria have war in a highly interdependent relationship which happens when:
   Condition Player 1: Player 1 is type *w* and Condition S is met

   $$Pr_{raid} < \frac{Pr_{wa} * W_1 + c_r - c}{W_2} - Pr_{wa} * b \ldots ConditionS$$

   Condition Player 2: Condition P is met

$$p_1 > \frac{W_2 - (Pr_{wd} * (W_2 - b * W_1) - c)}{(W_2 + b * 0.5T) - (Pr_{wd} * (W_2 - b * W_1) - c)} \quad \ldots Condition P$$

In this model, it is not necessary to consider when the known player is warlike. This is because of the assumption that warlike countries will always go to war. Therefore, if a player of an unknown type approaches a warlike country, then that player is also warlike since war in a highly interdependent relationship is the only possible equilibrium.

5.Discussion and Conclusion

In this paper, I portrayed how interdependence affects the benefits of trade and the benefits of war. Additionally, I analysed how based on those benefits, countries choose their interdependence level. Through the extensions, I explored how the inclusion of outside incentives and the presence of differing objectives affect the choice to trade and war and the choice of interdependence level respectively.

There are important policy implications from this paper. Firstly, by increasing trade surplus countries are able to reduce the possibility of war. This is in line with the conclusion from liberal theory. However, from the basic model, it is also evident that increasing the benefits of interdependence also increases the benefits of war. The only way to mitigate this and ensure a (trade, trade) equilibrium is by increasing the costs of war for the other country. One manner to increase the cost of war for the other country is by the country increasing its military defences. Through increasing its military defences, the other country has to incur a higher cost of war when attacking. Additionally, the inclusion of financial aid and financial sanctions increase the cost of starting war. This is because financial sanctions increase the cost of war, whereas financial aid increases the benefit of not starting wars. From the model in section 4.1, it is observable that financial sanctions and financial aid can work in tandem to lessen the probability of war. For example, if the cost of imposing financial sanctions are much higher than providing financial aid, outside countries can choose to increase their financial aid instead. By the inclusion of outside incentives, war is no longer a dominant strategy. Therefore, international law is necessary for ensuring pareto efficient equilibrium through both counties trading in a highly interdependent relationship. From the second extension, it was observed how the characteristics of a country can influence the probability of the other country being peaceful or warlike. For example, the higher the domestic production of a country or the higher the interdependence benefit, the more likely the other country is warlike. Through this, countries can use this knowledge of their production and economies of scale to determine the objective of the other player. Additionally, in this model there is no assumption of how a country can increase the accuracy of the probability distribution of the type of the other player. An extension from this, could in turn add parameters that improve the knowledge of the country with the known type about the type of the unknown player. For example, through knowledge of countries' foreign policies, espionage, and

more. It is evident that by countries increasing their knowledge of other countries this in turn helps to make more accurate judgments on the choices of trading partners.

Throughout this paper, certain assumptions have been made. Firstly, the probability of winning the war has been exogenous. In an extension to the model, the probability of winning the war could be determined partially by the power of the country and partially by first mover advantage. More weight in the probability could be given to the power of the country, this is because a stronger country would have a higher chance of winning the war, irrespective of first mover advantage. Secondly, there has been an assumption of a constant interdependence cost paid in the second stage. Further exploration into this topic could use the inclusion of a progressive interdependence cost. The addition of a progressive interdependence cost paid in the second stage of the game in which this cost could be proportional to the trade volume and gains from trade, because the higher the trade volume the higher the costs such as hold-up problems, global imbalances and more. This would help to explore the dynamic effects of interdependence costs during the choice of trade and war. Thirdly, there has been the assumption of trade in a generic basket of goods. An extension to this topic could explore how trade in different good types affect the choice of trade and war. For example, by exploring a war good and a non-war good for example guns and rice. Through this extension, an analysis could also be done on how through the increase in the price of guns a country can also increase the cost of war for another country. Furthermore, how the use of prices can reduce the chance of a (War, War) equilibrium. Regarding the inclusion of players with different objectives, there was the assumption of player with an unknown type and another with a known type. Relaxation of this assumption could instead focus on when both players are of unknown types and how that would affect the potential equilibriums.

Therefore, interdependence can be both a blessing and a curse. As a result, it is important for countries to understand how the coupling of their economies affects the choices of trade and war. Moreover, countries need to understand the true objectives behind trade proposals and also use international law for sovereignty protection.

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